BULLETIN OF THE
U.S. DEPARTMENT OF AGRICULTURE

No. 161

Contribution from the Bureau of Entomology, L. O. Howard, Chief.
December 18, 1914.

EXAMINED
FEB 1915
ENTOM.

THE MEDITERRANEAN FRUIT FLY IN BERMUDA.

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INTRODUCTION.

This paper is the result of an investigation of the fruit-fly situation in Bermuda, made by the writer during December, 1913, at the request of Mr. C. L. Marlatt, Assistant Chief of the Bureau of Entomology and chairman of the Federal Horticultural Board, in order to gain at first hand information that might be of value to the Horticultural Board in framing its quarantine regulations against this pest.

HISTORY OF THE FRUIT FLY IN BERMUDA.

The Mediterranean fruit fly, *Ceratitis capitata* Wied., was not recorded in literature from Bermuda until 1890, when Riley and Howard [1] report receiving specimens of infested peaches from St. George. However, it had been known as a pest in Bermuda many years before this date, as Mr. Claude W. McCallan, who forwarded these specimens to Washington, stated in his accompanying letter of April of that year that peaches had been subjected to its ravages during the 25 years previous. About the year 1865 a vessel carrying a cargo of fruit from the Mediterranean regions, bound for New York, was forced by severe storms to discharge her cargo in Bermuda, and it is the general belief that at that time the pest gained its foothold in this English possession. But whatever the source of infestation, it is a well-known fact that for nearly 50 years the peach industry of these islands has been a ruined one, and that at the present time the fruit fly is generally distributed over the islands ready to infest all host fruits coming to maturity.

LIFE HISTORY.

Those wishing a detailed description and life history of the Mediterranean fruit fly should refer to the publication of Quaintance,[2] published by the Department of Agriculture.

[1] Riley, C. V., and Howard, L. O. The peach pest in Bermuda. (*Ceratitis capitata* Wied.) Order Diptera: Family Trypetidæ. In U. S. Dept. Agr., Div. Ent., Insect life, v. 3, no. 1, p. 5–8, 2 figs., August, 1890.

[2] Quaintance, A. L. The Mediterranean fruit fly. U. S. Dept. Agr., Bur. Ent. Circ. no. 160, 25 p., 1 fig., Oct. 5, 1912.

Note.—This bulletin discusses the history of the fruit fly in Bermuda, the life history of the insect, and the possibility of eradicating it from Bermuda; the bulletin is of interest to entomologists.

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EGG, LARVA, AND PUPA.

Col. W. R. Winter, in his bulletin entitled "The Fruit Fly," published by the Bermuda Department of Agriculture in 1913,[1] gives the only data secured in Bermuda on this pest up to that date. He states that he has found that to pass through the egg, larval, and pupal stages the fly requires from 17 days, during the heat of August, when the monthly mean temperature averages about 81° F., to 6 weeks in winter, when the mean temperature averages about 63.2° F.

With the assistance of Mr. E. J. Wortley, Director of Agriculture of the Bermuda Department of Agriculture, the writer found that the pupal stage alone in Bermuda, when the daily mean temperatures ranged between 62.5° and about 64.8° F., might be lengthened to about 31 days under normal conditions.

Back and Pemberton have found that a temperature varying from 58° to 62° F. increases pupal life to from 29 to 31 days. They have likewise found that while eggs hatch in from 2 to 3 days in Hawaii at a mean temperature of about 79° F., hatching may be delayed until 6 days after deposition when the mean temperature drops to about 71° F., or until 7 to 14 days when the temperature ranges from 54° to 57° F. It has also been found in Hawaii that while the larval stage may require a minimum of 5 to 6 days at a mean temperature averaging about 79° F., it requires from 36 to 53 days in apples at temperatures ranging from 56° to 57° F.

These data are given to substantiate the belief of the writer that the duration of life from the egg to the adult in Bermuda where the winter mean averages about 63° F. is somewhat over two months, and may even be three months under unfavorable circumstances.

THE ADULT.

In the Hawaiian Islands, where the summers are somewhat cooler and the winters slightly warmer than in Bermuda, adult flies have been kept alive over five months. While the majority do not live this long, the belief has been expressed that a few flies may live to be over six months of age, especially during such cool weather as obtains in Bermuda during the winter. Both sexes are sexually immature when they emerge from the pupa. At temperatures varying from 76° to 78° F., the sexes mate when 5 to 8 days old, though not until 2 weeks old at 61° to 64° F. One prolific female deposited on an average of about 4.5 eggs per day during the first 18 weeks of her life, and had not then reached her egg-laying capacity. As many as 25 eggs have been laid by a single female in one day. Female flies do not lay a large number of eggs at one time and then die, as many believe, but lay quite regularly a few eggs nearly every day throughout life.

[1] Winter, W. R. The fruit fly. Bermuda, 1913. 14 p. (Bermuda Dept. Agr., E. J. Wortley, director.)

HOST FRUITS IN BERMUDA.

Col. W. R. Winter, in the bulletin previously mentioned, lists 47 fruits subject to attack. To this list for Bermuda should be added the ball kamani (*Calophyllum inophyllum*), the prickly pear (*Opuntia* sp.), and the acordia. While the list of host fruits given is so large that one receives the impression that the fruit fly has an abundance of fruit in which to develop, conditions are quite the opposite in Bermuda. After having carried on a clean-culture campaign against this pest in the Hawaiian Islands, where there exists a very great abundance of many host fruits, the writer was surprised at the scarcity of host fruits in Bermuda. In Table I is recorded the vegetation found growing in portions of the city of Hamilton.

TABLE I.—*Vegetation in Hamilton, Bermuda, with reference to host fruits for the Mediterranean fruit fly.*[1]

Kind of tree.	Number of different trees on various properties.[2]													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Apple													1	
Acalepha	1	1	1		1	1	1	1	1		1	10	6	7
Anona								1			1		2	1
Aracaria			1										3	
Avocado		1							1		1	2	6	11
Banana				1			1	1	1	1	1	75	24	65
Cedars	1	1	1			1	1	1	1	1		2	23	1
Chinaberry	1				1		1	1	1			2	8	15
Citrus									1					
Coffee					1									
Crape myrtle					1		1			1			3	1
Croton							1		1		1	10	6	4
Eugenia	1	1					1			1			2	
Fiddlewood		1							1			3	9	
Guava														
Hibiscus	1	1	1	1	1	1			1			12	6	4
Kamani, ball					1							1		1
Kamani, winged												1		
Loquats		1		1				1	1		1	12	22	10
Mango				1										1
Mulberry				1										1
Oleander		1	1			1	1	1	1			2	8	3
Pandanus	1		1		1							1		
Papaya			1	1			1	1	1	1		3	12	27
Peach								1					10	
Pigeonberry							1	1				2	2	4
Poinciana				1	1								1	1
Roses														
Rubber tree	1		1				1						1	1
Sapodilla					1			1				1		
Thevetia					1									

[1] All trees and shrubs were recorded except the following nonhost plants: Bamboo 5, buttonwood 5, Dracaena 3, elder 1, Lantana 3, Mimosa 2, pomegranate 1, privet 2, Australian pine 2, tamarind 1, sea grape 2, coconut palm 1, palmetto 8, date palm 8, sago palm 3, Poinsetta 2, Euphorbia 7, Althea 1. Host plants of the Mediterranean fruit fly are in italics.

[2] Nos 1 to 11 represent private premises; Nos. 12 to 14, city blocks.

The number of trees and shrubs in Bermuda which bear fruit subject to attack is very small. Out of 9,828 acres of land only 2,636 acres were recorded under cultivation in 1901, and this acreage has but slightly increased. The principal products raised for export, potatoes, onions, arrowroot, lily bulbs, and garden vegetables, except peppers, are not subject to attack. On the uncultivated areas the host fruits are mainly conspicuous by their absence. In such areas

the escaped Surinam cherry (*Eugenia micheli*) and a small species of prickly pear (Opuntia) are to be found in varying numbers. In the Tuckerstown district the former is quite abundant, while the latter is plentiful in sandy locations, as noted especially in Southampton Parish along the south shore. The soil of Bermuda, being very shallow, does not support dense vegetation. Cedar trees are so generally distributed over the islands that the landscape, as viewed from a tower, appears blackened by them. One can often walk among them long distances, as distances go in Bermuda, without seeing a single tree bearing fruit subject to attack. Often the cedar, fiddlewood (*Citharexylum quadrangulare*), the oleander (*Nerium oleander*), the Lantana (*Lantana odorata* and *L. crocea*), the life plant (*Bryophyllum calycinum*), grasses, and a few weeds are all that one sees. Some of the small islands of the group were found to support nothing subject to attack. In and about Tuckerstown and the adjoining limestone region the vegetation is more dense, and progress through the woods is made difficult by the presence of rocks and vines. In this region are to be found many neglected bittersweet oranges, whose fruits, according to Col. W. R. Winter, are quite eagerly gathered for marmalade, although often the trees are difficult of access.

It was found that the principal fruits supporting the fruit fly in Bermuda were:

(1) The loquat or Malta plum (*Eriobotrya japonica*), which ripens during January, February, and March.

(2) Peaches, which ripen during late March, April, May, June, and early July.

(3) Surinam cherries (*Eugenia micheli*), the first crop of which ripens during May and the second crop throughout summer and early fall.

Director of Agriculture Wortley informed the writer that the cultivated bell pepper was also a source of food for the fruit fly during the summer months.

AMOUNT OF FRUIT.

No large amount of fruit subject to infestation by the fruit fly is to be had in Bermuda at any season of the year unless it be during the time when Surinam cherries are in season. It would not be just to Bermuda horticulturists for one visiting these charming islands for so short a time during the winter to state that many of the more tropical fruit trees appeared stunted and grown only with great care in favored gardens; yet it so seemed to the writer. It would be very easy to count the number of apple, guava, mango, and bestill trees (Thevetia) in the islands. One common guava was pointed out in a beautiful garden as a curiosity. Only one winged kamani, one sweet almond (Terminalia) and one apple tree were seen. The avocado, citrus, papaya, and peach trees were more numerous, though by no

means plentiful. The loquat seemed to be the most abundant cultivated fruit, but few of the trees were as large or as well developed as those in Florida or Hawaii, and their ripening fruit was, at the time of the writer's visit, everywhere generally infested. Experimenters wishing to rear flies in large numbers for scientific purposes would be forced, in the opinion of the writer, to depend upon imported fruits, such as apples, in order to have a constant and satisfactory supply.

POSSIBILITY OF ERADICATION.

From the experience of the writer with clean cultural methods covering nearly two years in the city of Honolulu, Hawaiian Islands, he believes that the Mediterranean fruit fly can be eradicated from Bermuda within three years at the longest without the expenditure of a prohibitive amount of money. If the fruit flies were not capable of living so long in the adult stage, it is probable that the work of eradication could be accomplished in less time. There is probably no country in the world where the fruit fly exists in which the work of eradication could be undertaken with such assurance of success, provided the work were placed in the hands of a persistent, well-informed, intelligent person who could carry on an uninterrupted campaign authorized by adequate legislation. The fruits infested at the present time are such that no citizen would be forced to bear any real financial loss as the result of such a campaign. The peach and loquat fruits are practically all destroyed yearly by the fly, and the Surinam cherries are of no commercial value. By the judicious use of axe and saw and by thorough cutting of flowers or young fruit on those few trees that can not for various reasons be either cut down or prevented temporarily from bearing by severe pruning, the host fruits could be eliminated. It has already been shown that oranges and grapefruit act more as traps for the fruit fly than as hosts if allowed to remain on the tree until sufficiently ripe for table purposes, and such trees of value need not be destroyed provided the fruit be gathered before it becomes overripe.

The Bermuda agricultural authorities had already secured the passage of legislation against this pest and started clean cultural work as early as March, 1907, when the board of agriculture, as stated by Col. Winter in a letter to the writer under date of February 20, 1914, was given the power to "prohibit the growing of any fruit or vegetable, to clear off fruit, cut back or destroy as necessary any trees or vegetables, and to clean up the ground beneath them." The inspection work was already yielding good results when the fruit fly destruction act of 1907, under which it was being carried on, lapsed on December 31, 1910. No work was done during 1911 and 1912, although a new act was passed in June of the latter year. During 1913 inspections were again started, but apparently had accom-

plished little in controlling the fruit fly, as evidenced by the general infestation noted by the writer in ripe loquats and Thevetia in December of that year.

In other words, the money appropriated in Bermuda for inspection work against the fruit fly has not yielded practical results. The small amount of fruit grown in the islands does not warrant the expenditure of money except with the object of extermination in view. It is only by extermination that fruit growers in Bermuda can hope to produce those fruits which her climate makes possible without maintaining a system of inspection that at best will yield but temporary results and at the same time be a source of perpetual expense amounting to more than the fruits now grown are worth. The work carried on by the Federal Government in Hawaii has clearly demonstrated the fact that no clean cultural method will lead to any lasting beneficial result unless the person in charge of such work be given the power, either personally or through able inspectors, to plan the destruction of all fruit before it begins to ripen, either by the destruction or severe pruning of host trees or the gathering of fruit before it is sufficiently developed to become infested. Just so long as notices are served on residents demanding them to destroy fruits on their properties already known to the inspector to be infested with the fruit fly, just so long will failure attend clean-culture work. The director of a clean-culture campaign must have full power to destroy fruit whenever he knows that the facts demand it. Human nature is the same the world over. Lack of interest on the part of a few citizens when the destruction of fruit is left in their hands can defeat and has defeated the plans of the most able directors. These statements regarding clean-culture work are based upon the results following the expenditure of many thousand dollars in similar work in the Hawaiian Islands and elsewhere.

BERMUDA AS A SOURCE OF DANGER TO THE UNITED STATES.

If Bermuda were in direct communication with the southern Atlantic ports of the United States, to which she is so closely situated, she would be a source of great danger to the fruit interests of the Southern States. However, her only regular and direct communication is by means of vessels plying between Hamilton and New York, a distance of about 701 miles, for the passage of which about two days is required. Another line of steamers, equipped with limited passenger accommodations and running about every four weeks, connects London and Hamilton. The vessels of this last company usually continue on to Cuban ports, and thence to a southern port of the United States for freight before returning to England. Such small quantities of fruit are brought to maturity in an edible condition in Bermuda that there is very slight probability of any

being carried to the United States. Native-grown fruit is scarce and a luxury even for the few who are able to grow it. Practically all the fruit consumed in Bermuda and on the ships plying between Hamilton and New York is grown in the United States. Furthermore, the climatic conditions in and about New York are known to be decidedly against the establishment of the fruit fly, even if it should be accidentally introduced. The fact that ships have been plying between New York and Bermuda for many years without the pest having become established on the mainland is an argument in itself. Practically all agricultural produce grown in Bermuda can not be marketed profitably in New York, where it is for the most part consumed, unless it is placed on the market before that grown in the Southern States is shipped north. Thus the bulk of Bermuda-grown vegetables, whether subject to infestation or not, arrives in New York at a season when the climate is too cold for the pest to survive. With the addition at the present time of the strict quarantine regulations against all Bermuda-grown fruits or vegetables subject to attack, to the restrictions already placed by nature and the market, it would appear that Bermuda is a source of very little danger to the United States from the fruit-fly standpoint.

CONCLUSION.

The Mediterranean fruit fly, *Ceratitis capitata* Wied., was introduced into the Bermuda Islands probably about 1865, when fruit supposedly infested by this pest was unloaded there from a storm-tossed vessel from the Mediterranean region. Since that time the fruit fly has spread over the entire 19½ square miles of rolling country of which these islands are composed, and long since has ruined the excellent peach industry enjoyed by Bermuda in the early days and has caused such discouragement among prospective fruit growers that at the present time native-grown fruit in Bermuda is a luxury.

While Bermuda is probably at present a source of comparatively small danger to the United States as a source of infestation by the Mediterranean fruit fly, both on account of her trade relations and the climatic conditions surrounding New York, the extermination of the pest in these islands will be decidedly to the advantage of both Bermuda and the United States. All parts of Bermuda are easy of access. The topography is cut up by harbors, lakes, and roads into small areas that can be easily inspected; the trees and shrubs, the fruits of which are subject to infestation, are surprisingly few numerically, and a large portion of the uncultivated lands supports little that is subject to attack.

Experience in all countries where clean cultural work has been undertaken, but especially in the city of Honolulu, has shown that

no lasting beneficial results will follow such work as has been carried on in Bermuda unless extermination is the object in view. The value of the fruit grown in Bermuda is not sufficient to warrant work being carried on with any other object. In no country where the fly now exists could work of extermination be undertaken with such assurances of success as in Bermuda. If clean cultural work were supported continuously by adequate legislation and undertaken by a person sufficiently conversant with the problem and eager to make a unique record in the entomological world, the Mediterranean fruit fly could be exterminated from Bermuda within three years, without the expenditure of a prohibitive amount of money.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1914